CERTIFICATION

I, Masami Sano, 10-1 Higashikotari 1-chome, Nagaokakyo-shi, Kyoto-fu, Japan, do hereby certify that I am conversant with the English and Japanese language, and I further certify that to the best of my knowledge and belief that the attached English translation is a true and correct translation of the Japanese patent application No. **2003-061937** filed on March 7, 2003.

Date: June 29, 2005

Masami Sano

Masami Sano

[Name of Document] Application for Patent

[Reference No.] DP030043

[Date of Filing] March 7, 2003

[Addressee] Commissioner of the Patent Office

[Int. Cl.] H01P 7/08

[Inventor]

[Address] c/o Murata Manufacturing Co., Ltd., 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu

[Name] Seiji KANBA

[Inventor]

[Address] c/o Murata Manufacturing Co., Ltd., 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu

[Name] Naoki MIZOGUCHI

[Inventor]

[Address] c/o Murata Manufacturing Co., Ltd., 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu

[Name] Hisatake OKAMURA

[Applicant for Patent]

[Id. No.] 000006231

[Address] 26-10, Tenjin 2-chome, Nagaokakyo-shi, Kyoto-fu

[Name] Murata Manufacturing Co., Ltd.

[Agent]

[Id. No.] 100086597

[Patent Attorney]

[Name] Chikara MIYAZAKI

[Application Fees]

[Prepayment Registration No.] 004776

[Amount of Payment] 21000

[List of Documents Attached]

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[No. of General Power of Attorney] 9004892

[Proof] Required

[Name of Document] SPECIFICATION

[Title of the Invention] BANDPASS FILTER

[Claims]

[Claim 1] A bandpass filter comprising:

a dielectric substrate including a plurality of dielectric substrates;

a resonator electrode that is formed on a portion of a plane at a height in the thickness direction of the dielectric substrate so as to oppose the top face of the dielectric substrate and that includes an aperture;

first and second ground electrodes arranged over and under the resonator electrode, respectively, in the thickness direction of the dielectric substrate so as to oppose the resonator electrode with dielectric layers disposed therebetween and so as to sandwich the resonator electrode;

input-output coupling electrodes coupled to the resonator electrode; and

input-output terminal electrodes that are formed on the outside surface of the dielectric substrate and that are electrically connected to the input-output coupling electrodes,

wherein the bandpass filter is characterized by having a via-hole electrode that penetrates through the aperture in the thickness direction of the dielectric substrate so as

not to be electrically connected to the resonator electrode and that is electrically connected to the first and second ground electrodes.

[Claim 2] A bandpass filter according to Claim 1, further comprising second via-hole electrodes that are arranged in an area outside the resonator electrode in plan view of the resonator electrode and that are electrically connected to the first and second ground electrodes.

[Claim 3] A bandpass filter according to Claim 1 or 2, wherein the resonator electrode is structured so as to have a plurality of non-degenerate resonant modes and such that the plurality of resonant modes are coupled to each other owing to the aperture to constitute a dual-mode bandpass filter.

[Claim 4] A bandpass filter according to Claim 1 or 2, wherein the resonator electrode is a ring resonator electrode.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to bandpass filters used in, for example, communication equipment for the band from microwaves to millimeter waves and, more particularly, to a bandpass filter having a structure for suppressing spurious signals occurring depending on the positional relationship

between ground electrodes and a resonator electrode.

[0002]

[Description of the Related Art]

Hitherto, various dual-mode bandpass filters have been suggested as bandpass filters for use in high-frequency bands.

[0003]

For example, a dual-mode bandpass filter that uses a resonator electrode having an aperture is disclosed in Patent Document 1 described below. As shown in a cross-sectional front view in Fig. 17(a) and a schematic plan view in Fig. 17(b), a dual-mode bandpass filter 101 has a dielectric substrate 102. A resonator electrode 103 is formed at an intermediate height in the dielectric substrate 102. The resonator electrode 103 has an aperture 103a (an area where no electrode is formed in the resonator electrode 103). The resonator electrode 103 has a plurality of non-degenerate resonant modes. The aperture 103a is formed for coupling the resonant modes to each other to constitute the dual-mode bandpass filter. Ground electrodes 104 and 105 are formed beneath the top face and on the bottom face of the dielectric substrate 102, respectively, so as to oppose the resonator electrode 103. As shown in Fig. 17(b), input-output coupling electrodes 106 and 107 are coupled to the resonator electrode 103. The input-output coupling

electrodes 106 and 107 extend outside the resonator electrode 103, although not shown in Fig. 17(a), and are electrically connected to the corresponding input-output terminal electrodes (not shown).

[0004]

[Patent Document 1]

Japanese Unexamined Patent Application Publication No. 2001-237610

[0005]

[Problems to be Solved by the Invention]

Usually, in a bandpass filter, such as the dual-mode bandpass filter 101, having a structure in which the ground electrodes are formed over and under the resonator electrode with dielectric layers of the dielectric substrate disposed therebetween, ground electrodes are also formed on side faces of the dielectric substrate 102. Accordingly, the ground electrodes serve as a waveguide; that is, the resonator electrode 103 is provided in a waveguide. With such a structure, resonances occur depending only on the shape of the waveguide. The structure, similar to a waveguide, including the ground electrodes is consequently larger than the resonator electrode 103.

[0006]

The fundamental resonances caused by the ground electrodes occur at frequencies lower than the resonant

frequency of the resonator electrode 103, and higher-mode resonances are apt to sequentially occur at overlapping positions with resonant modes caused by the resonator electrode 103. Such resonances caused by the ground electrodes become undesired spurious signals in the dual-mode bandpass filter 101, so that it is impossible to achieve good transmission characteristics.

[0007]

Accordingly, in order to solve the above problem, it is an object of the present invention to provide a bandpass filter capable of suppressing undesired spurious signals caused by the resonances of the ground electrodes to achieve good transmission characteristics.

[0008]

[Means for Solving the Problems]

A bandpass filter of present invention includes a dielectric substrate including a plurality of dielectric substrates; a resonator electrode that is formed on a portion of a plane at a height in the thickness direction of the dielectric substrate so as to oppose the top face of the dielectric substrate and that includes an aperture; first and second ground electrodes that are arranged over and under the resonator electrode, respectively, in the thickness direction of the dielectric substrate so as to oppose the resonator electrode with dielectric layers

disposed therebetween and so as to sandwich the resonator electrode; input-output coupling electrodes coupled to the resonator electrode; and input-output terminal electrodes that are formed on the outside surface of the dielectric substrate and that are electrically connected to the input-output coupling electrodes. The bandpass filter is characterized by having a via-hole electrode that penetrates through the aperture in the thickness direction of the dielectric substrate so as not to be electrically connected to the resonator electrode and that is electrically connected to the first and second ground electrodes.

[0009]

The bandpass filter of the present invention further has, in a certain aspect, second via-hole electrodes that are arranged in an area outside the resonator electrode in plan view of the resonator electrode and that are electrically connected to the first and second ground electrodes.

[0010]

In another certain aspect of the bandpass filter of the present invention, the resonator electrode, which has the aperture, is a metal film causing a plurality of resonant modes and is structured such that the plurality of resonant modes are coupled to each other owing to the aperture to constitute the dual-mode bandpass filter.

[0011]

In another certain aspect of the bandpass filter of the present invention, the resonator electrode is a ring resonator electrode. In such a case, controlling the coupling points to the input-output coupling electrodes provides the dual-mode bandpass filter.

[0012]

[Description of the Embodiments]

The present invention will be further illustrated with embodiments with reference to the drawings.

[0013]

Fig. 1(a) is a perspective view of a dual-mode bandpass filter according to a first embodiment of the present invention. Fig. 1(b) is a bottom view of the dual-mode bandpass filter. Fig. 1(c) is a cross-sectional side view of the dual-mode bandpass filter.

A dual-mode bandpass filter 1 has a rectangular dielectric substrate 2. The dielectric substrate 2 is made of a suitable dielectric material. Such dielectric material includes synthetic resin such as fluoroplastic and dielectric ceramics.

[0014]

The dielectric substrate 2 has a resonator electrode 3 and input-output coupling electrodes 4 and 5 formed at an intermediate height. The planar shape of the resonator

electrode 3 and the input-output coupling electrodes 4 and 5 is schematically shown in a plan view in Fig. 2. The resonator electrode 3, which has a rectangular shape, has an aperture 3a at its central part. The resonator electrode 3 is made of metal whose composition is not particularly limited, such as metal including aluminum or copper or alloy. The input-output coupling electrodes 4 and 5 are also formed of similar metallic material.

[0015]

The resonator electrode 3, which is a metal film, is formed on a portion of a plane at an intermediate height in the dielectric substrate 2.

The input-output coupling electrodes 4 and 5 may be arranged at any appropriate positions as long as they are capable of being coupled to the resonator electrode 3. That is, the input-output coupling electrodes 4 and 5 may be formed at a height different from the height at which the metal film 3 is formed.

[0016]

The resonator electrode 3 has a shape so as to generate a plurality of non-degenerate resonant modes. Since the resonator electrode 3 has the aperture 3a, the plural resonant modes are coupled to each other to provide the bandpass filter characteristics. Such a bandpass filter is disclosed in Patent Document 1 described above.

[0017]

In the dual-mode bandpass filter 1, a first ground electrode 6 is formed on an upper level of the dielectric substrate 2 so as to oppose the resonator electrode 3 with dielectric layers therebetween. Although the first ground electrode 6 is formed inside the dielectric substrate 2, it may be formed on the top face of the dielectric substrate 2.

[0018]

A second ground electrode 7 is formed beneath the bottom face of the dielectric substrate 2 so as to oppose the resonator electrode 3 with dielectric layers therebetween. It is not necessary to form the second ground electrode 7 beneath the dielectric substrate 2. The second ground electrode 7 may be embedded at a height above the bottom face of the dielectric substrate 2.

[0019]

The first ground electrode 6 and the second ground electrode 7 are larger than the resonator electrode 3 so as to sandwich the resonator electrode 3 between the first ground electrode 6 and the second ground electrode 7.

As shown in Fig. 1(a), third ground electrodes 8, 8 are formed on opposing sides of the dielectric substrate 2. The third ground electrodes 8, 8 are electrically connected to the first ground electrode 6 and the second ground electrode 7.

[0020]

As shown in Fig. 1(c), a first via-hole electrode 9 is formed so as to penetrate through the aperture 3a in the resonator electrode 3. The first via-hole electrode 9 is electrically connected to the first ground electrode 6 and the second ground electrode 7.

[0021]

The input-output coupling electrode 4 is electrically connected to an input-output terminal electrode 10 through a third via-hole electrode 12, and the input-output coupling electrode 5 is electrically connected to an input-output terminal electrode 11 through a third via-hole electrode 13. The input-output terminal electrodes 10 and 11 are provided beneath the bottom face of the dielectric substrate 2.

[0022]

The operation and effect of the dual-mode bandpass filter according to the first embodiment will now be described.

When input signals are supplied from one of the input-output terminal electrodes 10 and 11 to the dual-mode bandpass filter 1 according to the first embodiment, which has the structure in which the resonator electrode 3 and the aperture 3a are formed in the manner described above, the plural non-degenerate resonant modes occur in the resonator electrode 3. The resonant modes are coupled to each other

owing to the formation of the aperture 3a, so that the other electrode of the input-output terminal electrodes 10 and 11 yields bandpass filter characteristics.

[0023]

As described above, the resonator electrode 3 is surrounded by the first ground electrode 6, the second ground electrode 7, and the third ground electrodes 8 in a dual-mode bandpass filter 1 of this type. Namely, the first ground electrode 6, the second ground electrode 7, and the third ground electrodes 8 serve as a waveguide and, therefore, the resonance in the waveguide is apt to be spurious.

[0024]

In contrast, with the dual-mode bandpass filter 1 according to the first embodiment, the formation of the first via-hole electrode 9 suppresses undesirable spurious signals caused by the resonances of the first ground electrode 6, the second ground electrode 7, and the third ground electrodes 8. This will be described below with reference to Figs. 3 to 7 based on specific experiments.

[0025]

In the experiments below, the size of the dielectric substrate used, which is made of ceramic including magnesium and silicon as primary ingredients, is 2.5 mm wide by 3.2 mm long by 1.0 mm thick. The resonator electrode 3 has a size

of 1.4 mm wide by 1.5 mm long, and the aperture has an area of 0.54 mm^2.

[0026]

Fig. 3 shows S-parameter frequency characteristics in a structure where the resonator electrode 3 and the first via-hole electrode 9 are removed from the dual-mode bandpass filter 1 according to the first embodiment. Fig. 3 shows that resonance indicated by an arrow A occurs at a frequency of 26.46 GHz for a characteristic S11. This resonance corresponds to the resonance resulting from the structure having the first ground electrode 6, the second ground electrode 7, and the third ground electrodes 8. Namely, the fundamental resonance caused by the first to third ground electrodes 6 to 8 occurs at 26.46 GHz.

[0027]

Fig. 4 shows S-parameter frequency characteristics when only the resonator electrode 3 is removed from the dual-mode bandpass filter 1 according to the first embodiment. That is, the structure in Fig. 4 is different from the structure having the transmission characteristics shown in Fig. 3 except for the provision of the first via-hole electrode 9.

[0028]

As shown by an arrow Aa in Fig. 4, the provision of the via-hole electrode 9 causes the fundamental resonance caused by the first to third ground electrodes 6 to 8 to occur at a

frequency of 31.32 GHz.

[0029]

The comparison between Fig. 3 and Fig. 4 shows that the provision of the first via-hole electrode increases the frequency of the fundamental resonance caused by the ground electrodes 6 to 8 by about 5 GHz.

[0030]

Hence, the provision of the first via-hole electrode 9 shifts the frequency of the fundamental resonance and the frequency of a higher-mode resonance caused by the ground electrodes 6 to 8 toward higher frequencies.

[0031]

Fig. 5 shows S-parameter frequency characteristics in the structure shown in Fig. 1. Referring to Fig. 5, the resonant modes around a frequency of 25.5 GHz represent the resonant modes caused by the resonator electrode 3. The resonant modes are coupled to each other owing to the formation of the aperture 3a, thus achieving the bandpass filter characteristic. In contrast, the resonance caused by the ground electrodes 6 to 8 occurs at a frequency of 30.73 GHz, as shown by an arrow Ab. Accordingly, as shown in Fig. 5, the resonant frequency of the resonator electrode 3 for providing the bandpass filter characteristics is different from the resonant frequency of the ground electrodes 6 to 8.

[0032]

For comparison, the transmission characteristics of a known dual-mode bandpass filter 121 shown in Fig. 6 were measured. The dual-mode bandpass filter 121 is structured in the same manner as the dual-mode bandpass filter in Fig. 1 except for the removal of the first via-hole electrode 9.

[0033]

As shown in Fig. 7, the resonances caused by the resonator electrode 3 occur around a frequency of 27.7 GHz in the known dual-mode bandpass filter 121. The resonances caused by the ground electrodes occur at 25.58 GHz and 32.49 GHz, as shown by arrows Ac and Ad. That is, the fundamental resonances and the higher-mode resonances caused by the ground electrodes occur at both sides of the passband of the dual-mode bandpass filter 121.

[0034]

The comparison between Fig. 5 and Fig. 7 shows that, in the dual-mode bandpass filter 1 according to the first embodiment, the provision of the first via-hole electrode 9 alleviates the effect of undesirable spurious signals caused by the resonances of the ground electrodes 6 to 8, thus achieving good transmission characteristics.

[0035]

The first via-hole electrode 9 is formed such that the resonance caused by the ground electrodes arranged so as to surround the resonator electrode occurs outside the passband

of the dual-mode bandpass filter, as described above. This formation alleviates the effect of undesirable spurious signals caused by the ground electrodes, thus achieving good transmission characteristics, as in the first embodiment.

[0036]

Since the ground electrodes 6 to 8 are provided so as to surround the resonator electrode 3 in the dual-mode bandpass filter 1 according to the first embodiment, the radiation from the resonator electrode 3 is suppressed to suppress an increase in the insertion loss of the filter caused by radiation loss and to prevent the dual-mode bandpass filter from acting as a noise source. A shift in filter characteristics, which occurs when other electronic parts, a casing, or the like are close to the dual-mode bandpass filter 1, is also suppressed.

[0037]

The reasons why the spurious signals caused by the resonances of the ground electrodes 6 to 8 are shifted by providing the via-hole electrode 9 will be described below.

[0038]

Fig. 8 includes a plan view and a cross-sectional front view schematically showing the electric field distribution at the fundamental resonant frequency of the ground electrodes 6 to 8, that is, the electric field distribution at 26.46 GHz, in the dual-mode bandpass filter 1. In this

electric field distribution, the electric field strengthens as the density of black stripes increases. As shown in Fig. 8, a strong electric field occurs at the central part on the main surface of the dielectric substrate.

[0039]

In contrast, Fig. 9 includes a plan view and a cross-sectional front view schematically showing the electric field distribution at the fundamental resonant frequency of the ground electrodes 6 to 8, that is, the electric field distribution at 31.32 GHz, in the dual-mode bandpass filter according to the first embodiment having the first via-hole electrode 9. As shown in Fig. 9, the provision of the first via-hole electrode 9 at the central part of the main surface of the dielectric substrate eliminates the strong electric field in Fig. 8.

[0040]

In other words, since the via-hole electrode 9 is short-circuited to the ground electrodes 6 and 7, the electric field does not occur in and around an area where the via-hole electrode 9 is provided. Hence, according to the first embodiment, the formation of the via-hole electrode 9 makes the occurrence of a strong resonance at the central part of the dielectric substrate difficult, or causes the periphery of the via-hole electrode 9 not to contribute to the resonance caused by the ground electrodes

6 to 8. As a result, the structure serving as the waveguide can be reduced in size to increase the frequency of the fundamental resonance caused by the ground electrodes 6 to 8.

[0041]

Fig. 10(a) is a plan view of a dual-mode bandpass filter according to a second embodiment of the present invention. Fig. 10(b) is a cross-sectional side view of the dual-mode bandpass filter taken along line X2-X2 in Fig. 10(a).

[0042]

A dual-mode bandpass filter 21 of the second embodiment is structured in the same manner as the dual-mode bandpass filter 1 of the first embodiment except that second via-hole electrodes 22 to 25 are provided. In the plan view of the dual-mode bandpass filter 21, the plural second via-hole electrodes 22 to 25 are provided outside an area where the resonator electrode 3 is provided. The via-hole electrodes 22 to 25 are electrically connected to the first ground electrode 6 and the second ground electrode 7, like the first via-hole electrode 9.

[0043]

In the dual-mode bandpass filter 21, the provision of the second via-hole electrodes 22 to 25 shifts undesired spurious signals caused by the ground electrodes 6 to 8 toward higher frequencies to lessen the effect of the

spurious signals. This will be described below with reference to Figs. 11 to 13.

[0044]

Fig. 11 shows S-parameter frequency characteristics of the dual-mode bandpass filter. The fundamental resonance caused by the ground electrodes 6 to 8 occurs at 30.73 GHz in Fig. 5, showing the transmission characteristics of the dual-mode bandpass filter 1 according to the first embodiment, while the fundamental resonance caused by the ground electrodes 6 to 8 occurs at a higher frequency of 33.56 GHz in Fig. 11. Referring to Fig. 11, the resonances caused by the resonator electrode 3 occur around 25.5 GHz.

[0045]

In the dual-mode bandpass filter 21 according to the second embodiment, the addition of the second via-hole electrodes 22 to 25 can shift undesired spurious signals caused by the ground electrodes 6 to 8 toward higher frequencies to further lessen the effect of the spurious signals. This is probably because the provision of the second via-hole electrodes 22 to 25 produces an area that does not contribute to the resonance around the second via-hole electrodes 22 to 25, thus reducing the size of the structure serving as the waveguide, compared with the dual-mode bandpass filter of the first embodiment, and increasing the resonant frequency of the ground electrodes 6 to 8.

[0046]

With the dual-mode bandpass filter 21, it is also possible to reduce the frequency variation due to manufacturing errors. It is assumed that the width W of the dual-mode bandpass filter is decreased to W1 due to the manufacturing errors, as shown in the diagram at the right in Fig. 12.

[0047]

Fig. 13 shows S-parameter frequency characteristics of the dual-mode bandpass filter 1 when the resonator electrode 3 is removed and when the width is decreased as described above. Fig. 14 shows S-parameter frequency characteristics of the dual-mode bandpass filter 21 when the resonator electrode 3 is removed and when the width is decreased as described above.

[0048]

The comparison between Fig. 13 and Fig. 4 shows that, when the width is decreased due to the manufacturing errors in the dual-mode bandpass filter 1, the fundamental resonant frequency of the spurious signals caused by the resonances of the ground electrodes 6 to 8 shifts from 31.32 GHz to 32.87 GHz.

[0049]

The comparison between Fig. 11 and Fig. 14 shows that, when the width is decreased in the dual-mode bandpass filter

21 of the second embodiment, the fundamental resonant frequency of resonance caused by the ground electrodes shifts from 33.56 GHz to 33.98 GHz.

[0050]

In the dual-mode bandpass filter 21, the shift in the resonant frequency of the spurious signals when the chip size varies is small, compared with the shift in the dual-mode bandpass filter 1. In other words, the variation in the frequency of the spurious signals caused by the variation in the chip size resulting from the manufacturing errors can be reduced in the dual-mode bandpass filter 21, thus reducing the variation in the transmission characteristics.

[0051]

The reasons why the variation in the frequency of the spurious signals caused by the variation in the chip size can be reduced in the dual-mode bandpass filter 21, as described above, will be described below.

[0052]

In the dual-mode bandpass filter 1, the variation in width changes the size of spaces between the central first via-hole electrode 9 and both longitudinal sides of the dual-mode bandpass filter 1. Since the resonance in a transverse electric (TE) mode depends on the size of the spaces, the frequency varies with the variation in the size

of the spaces.

[0053]

In contrast, in the dual-mode bandpass filter 21, since the spaces are fixed by the second via-hole electrodes 22 to 25 around the resonator electrode 3 and the central first via-hole electrode 9, any variation in the width of the chip does not cause a change in the size of the spaces. Hence, the variation in the spurious signals caused by the manufacturing errors can be probably suppressed in the dual-mode bandpass filter 21.

[0054]

As shown in a modified dual-mode bandpass filter 26 in Fig. 15, the first ground electrode 6 and the second ground electrode 7 may be provided inside the dielectric substrate 2.

Although the aperture as disclosed in Patent Document 1 causes the plural non-degenerate resonant modes to be coupled to each other to provide the bandpass filter characteristics in the dual-mode bandpass filter 1 of the first embodiment and the dual-mode bandpass filter 21 of the second embodiment, the present invention is not limited to such bandpass filters. For example, the present invention can also be applied to a known dual-mode bandpass filter in Fig. 16, having a ring resonator electrode 31, in which controlling coupling points 32 and 33 to the ring resonator

electrode 31 provides the dual-mode bandpass filter characteristics. A feedback circuit 34 is used to control the degree of coupling in the dual-mode bandpass filter in Fig. 16.

[0055]

As described above, the present invention can be applied to various bandpass filters using resonator electrodes with various shapes, as long as the resonator electrodes have the respective apertures.

[0056]

[Advantages]

The bandpass filter of the present invention has the structure in which at least first and second ground electrodes are arranged over and under the resonator electrode so as to sandwich the resonator electrode. The bandpass filter has the via-hole electrode that penetrates through the aperture in the resonator electrode and that is electrically connected to the first and second ground electrodes. The provision of the via-hole electrode can shift the frequency of undesired spurious signals caused by the ground electrodes to achieve good transmission characteristics that are difficult to be affected by the spurious signals.

[0057]

The provision of the second via-hole electrodes in an

area outside the resonator electrode can cause the undesired spurious signals caused by the resonances of the ground electrodes to be further apart from the passband of the bandpass filter to achieve better transmission characteristics. The formation of the second via-hole electrodes makes it difficult to cause the variation in the frequency of the spurious signals even when any variation in the chip size is caused by the manufacturing errors of the bandpass filter. Hence, it is possible to realize the bandpass filter having less variation in characteristics caused by the manufacturing errors.

[0058]

When the resonator electrode is structured so as to have the plural non-degenerate resonant modes and such that the resonant modes are coupled to each other owing to the aperture to constitute the dual-mode bandpass filter, it is possible to easily realize the bandpass filter that has no restriction on the coupling points to the resonator electrode and provides various band characteristics by selecting the shapes of the resonator electrode and the aperture.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1(a) is a perspective view of a dual-mode bandpass filter according to a first embodiment; Fig. 1(b) is a

bottom view of the dual-mode bandpass filter of the first embodiment; and Fig. 1(c) is a cross-sectional side view of the dual-mode bandpass filter of the first embodiment taken along line X1-X1 in Fig. 1(b).

[Fig. 2]

Fig. 2 is a plan view schematically showing a resonator electrode and input-output coupling electrodes of the dual-mode bandpass filter of the first embodiment.

[Fig. 3]

Fig. 3 shows S-parameter frequency characteristics in a structure where a first via-hole electrode and the resonator electrode are removed from the dual-mode bandpass filter of the first embodiment.

[Fig. 4]

Fig. 4 shows S-parameter frequency characteristics in a structure where the resonator electrode are removed from the dual-mode bandpass filter of the first embodiment.

[Fig. 5]

Fig. 5 shows S-parameter frequency characteristics of the dual-mode bandpass filter of the first embodiment.

[Fig. 6]

Fig. 6 is a bottom view schematically showing a known dual-mode bandpass filter for comparison.

[Fig. 7]

Fig. 7 shows S-parameter frequency characteristics of

the known dual-mode bandpass filter shown in Fig. 6.

[Fig. 8]

Fig. 8(a) is a plan view and Fig. 8(b) is a cross-sectional front view schematically showing the electric field distribution of a known dual-mode bandpass filter having no via-hole electrode.

[Fig. 9]

Fig. 9(a) is a plan view and Fig. 9(b) is a cross-sectional front view schematically showing the electric field distribution of the dual-mode bandpass filter of the first embodiment.

[Fig. 10]

Fig. 10(a) is a bottom view of a dual-mode bandpass filter according to a second embodiment; and Fig. 10(b) is a cross-sectional side view of the dual-mode bandpass filter of the second embodiment taken along line X2-X2 in Fig. 10(a).

[Fig. 11]

Fig. 11 shows S-parameter frequency characteristics of the dual-mode bandpass filter of the second embodiment.

[Fig. 12]

Fig. 12 includes schematic plan views illustrating a case in which the width of the dual-mode bandpass filter is decreased.

[Fig. 13]

Fig. 13 shows S-parameter frequency characteristics of the dual-mode bandpass filter of the first embodiment when the resonator electrode is removed and when the width is varied.

[Fig. 14]

Fig. 14 shows S-parameter frequency characteristics of the dual-mode bandpass filter of the second embodiment when resonator electrode is removed and when the width is decreased.

[Fig. 15]

Fig. 15 is a cross-sectional front view showing a modification of the dual-mode bandpass filter of the present invention.

[Fig. 16]

Fig. 16 is a plan view schematically showing another modification of the dual-mode bandpass filter of the present invention.

[Fig. 17]

Fig. 17(a) is a cross-sectional front view and Fig. 17(b) is a plan view schematically showing a known dual-mode bandpass filter.

[Reference Numerals]

1: dual-mode bandpass filter

2: dielectric substrate

3: resonator electrode

3a: aperture

4, 5: input-output coupling electrodes

6, 7: first and second ground electrodes

8: third ground electrode

9: first via-hole electrode

10, 11: input-output terminal electrodes

12, 13: third via-hole electrodes

21: dual-mode bandpass filter

22 to 25: second via-hole electrodes

26: dual-mode bandpass filter

31: resonator electrode

JP Application No. 2003-061937

[Name of Document] ABSTRACT

[Abstract]

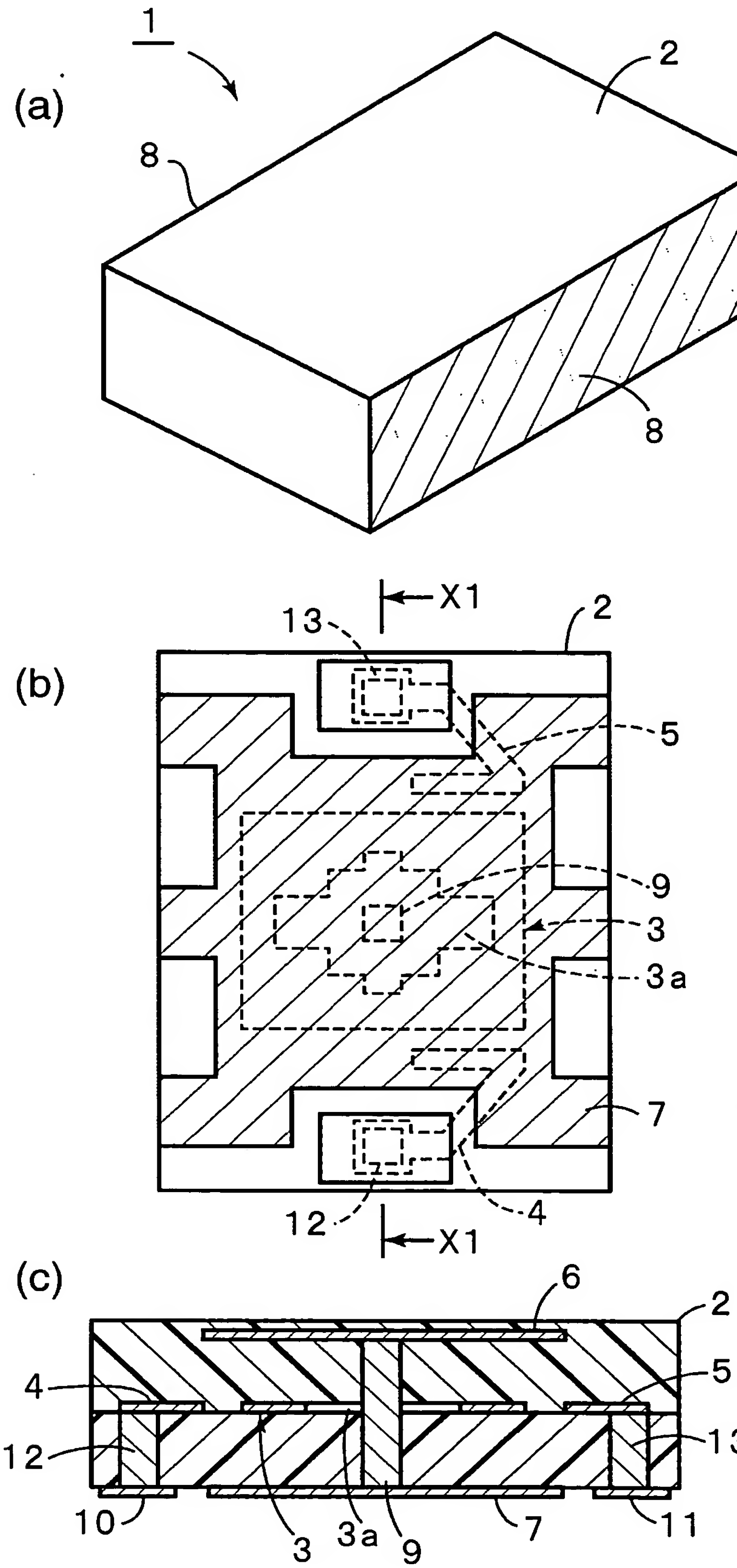
[Object] To provide a dual-mode bandpass filter capable of suppressing undesired spurious signals caused by the resonances of ground electrodes surrounding a resonator electrode to achieve good transmission characteristics.

[Solving Means] A bandpass filter 1 includes a resonator electrode 3 that is formed on a portion of a plane at a height in the thickness direction of a dielectric substrate 2 including a plurality of dielectric substrates so as to oppose the top face of the dielectric substrate and that includes an aperture 3a; first and second ground electrodes 6 and 7 arranged over and under the resonator electrode, respectively, so as to oppose the resonator electrode 3 with dielectric layers disposed therebetween; input-output coupling electrodes 4 and 5 coupled to the resonator electrode; and a via-hole electrode 9 that penetrates through the aperture 3a in the thickness direction of the dielectric substrate so as not to be electrically connected to the resonator electrode 3 and that is electrically connected to the first and second ground electrodes 6 and 7.

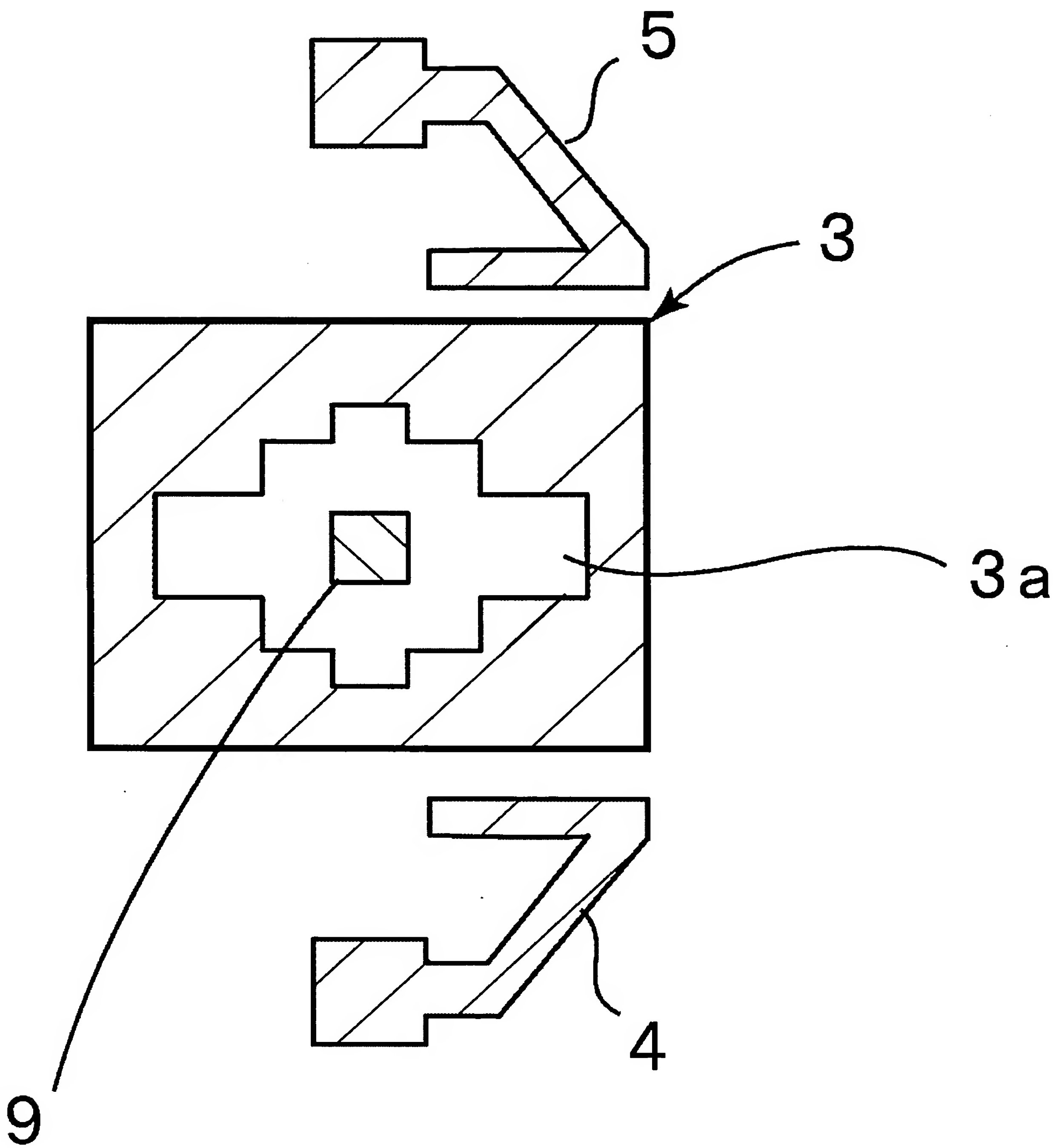
[Selected Figure] Fig. 1

【書類名】　　図面　[Name of Document] DRAWINGS

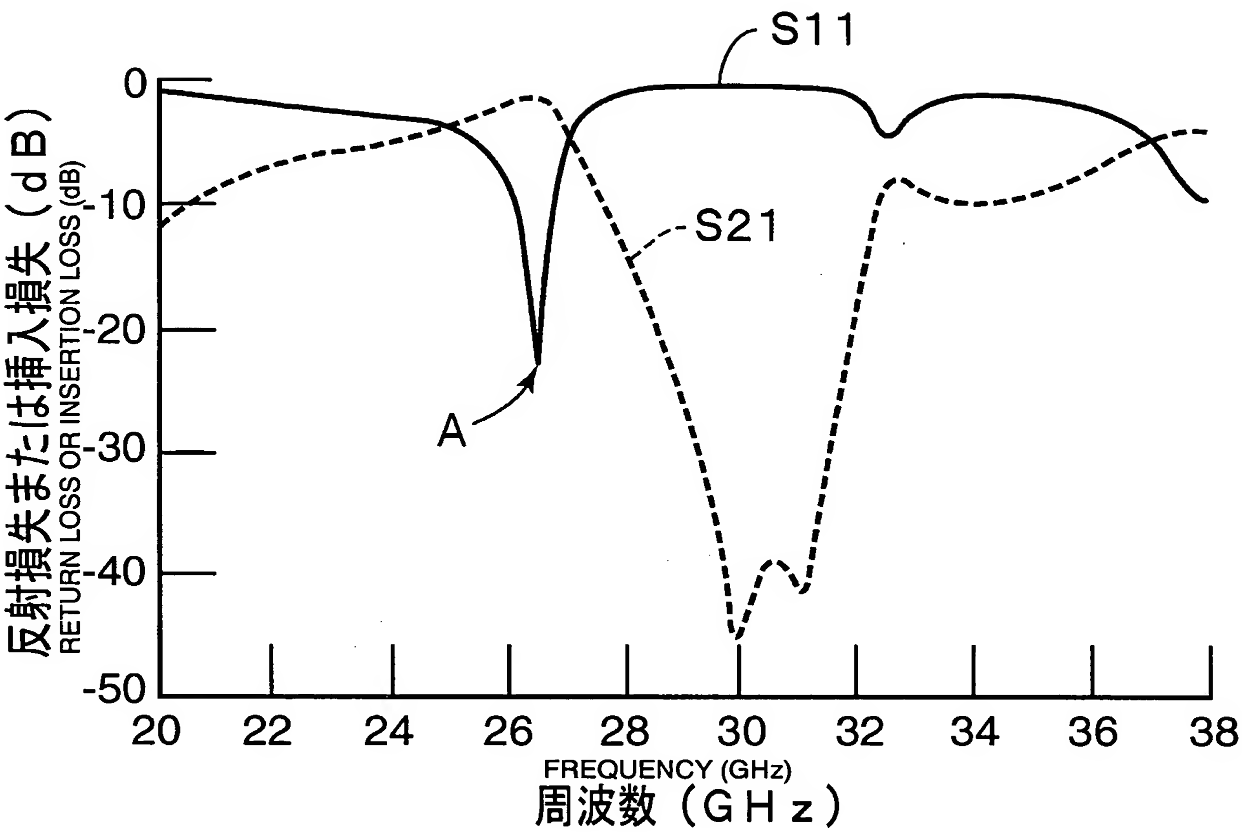
【図１】 [FIG. 1]



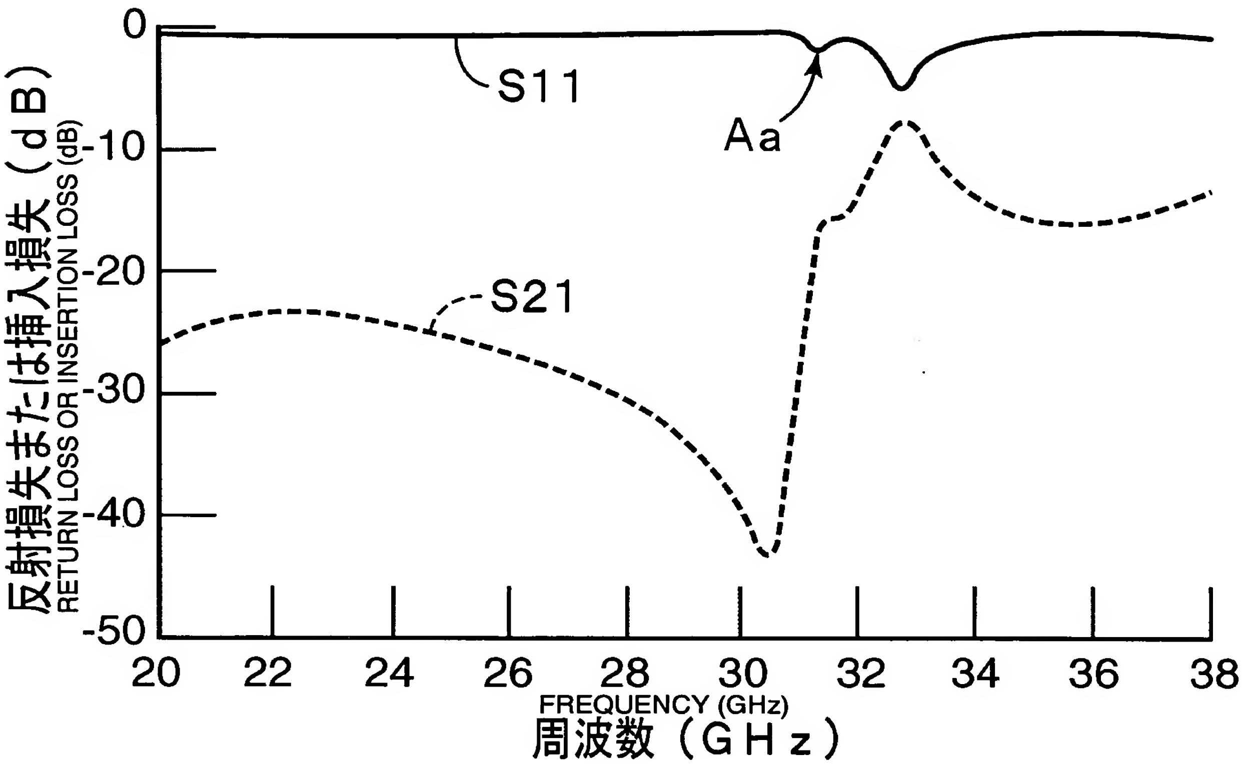
【図２】 [FIG. 2]



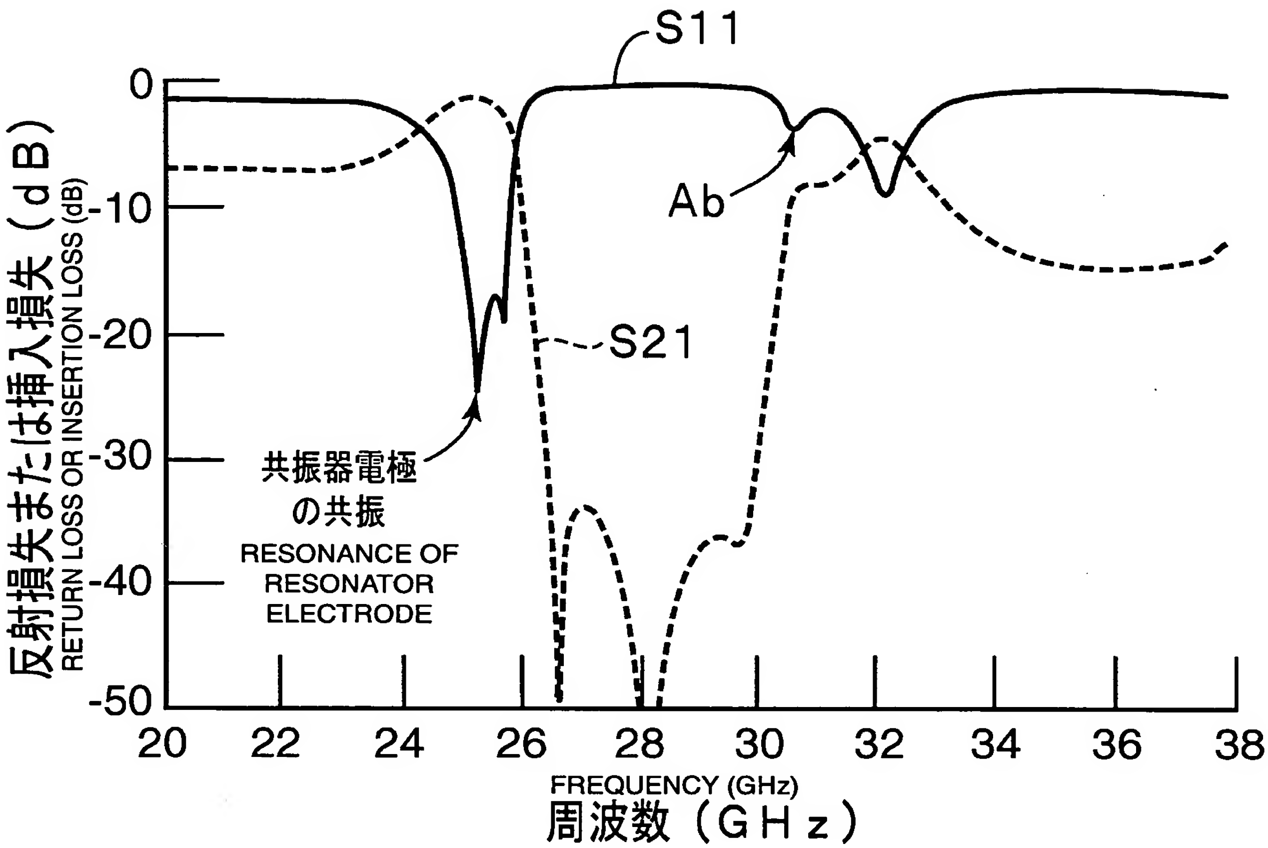
【図３】 [FIG. 3]


S11
S21
A
0
-10
-20
-30
-40
-50
20
22
24
26
28
30
32
34
36
38
反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
FREQUENCY (GHz)
周波数（ＧＨｚ）

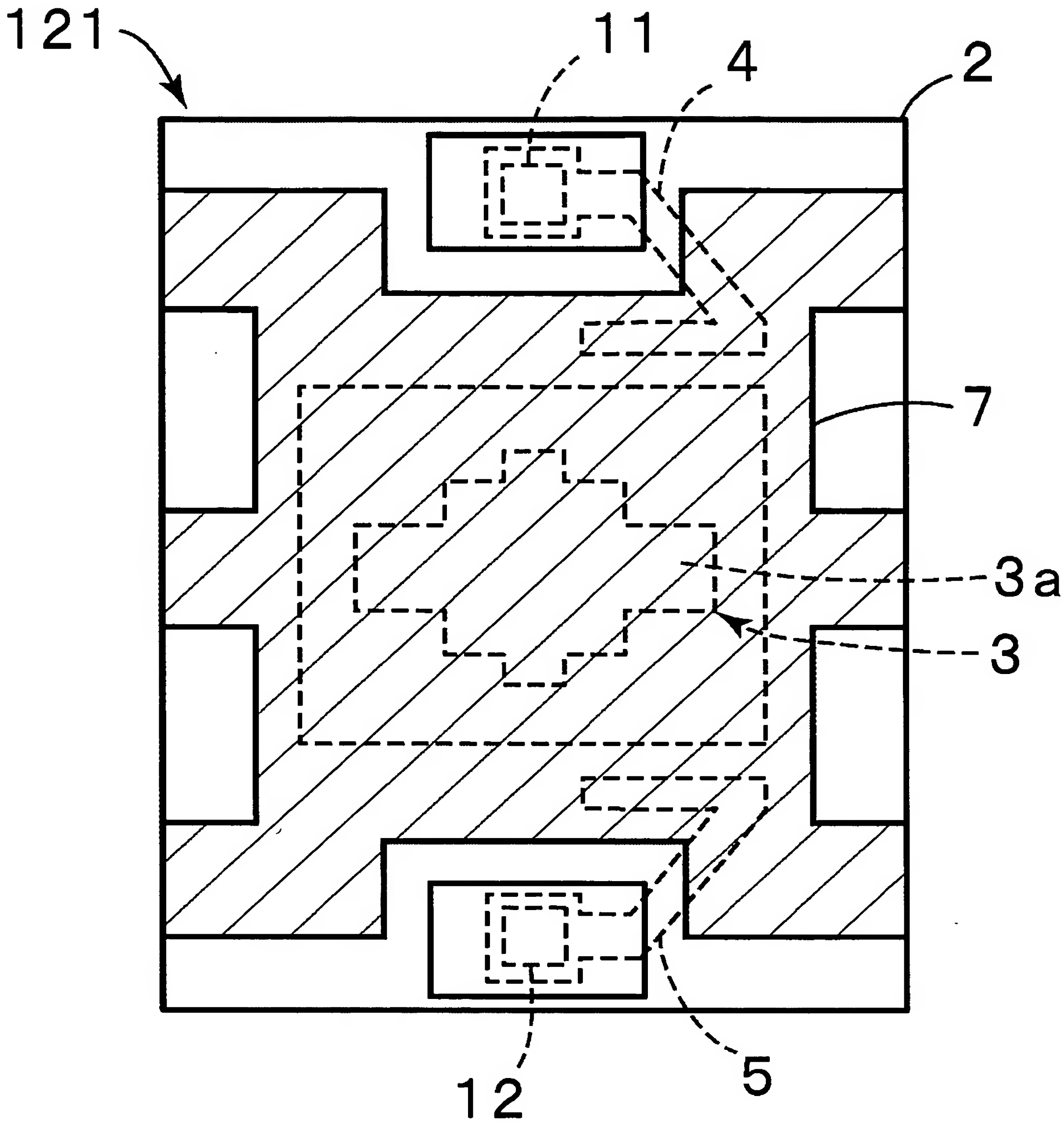
【図４】 [FIG. 4]


0
-10
-20
-30
-40
-50
S11
Aa
S21
20
22
24
26
28
30
32
34
36
38
反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
FREQUENCY (GHz)
周波数（ＧＨｚ）

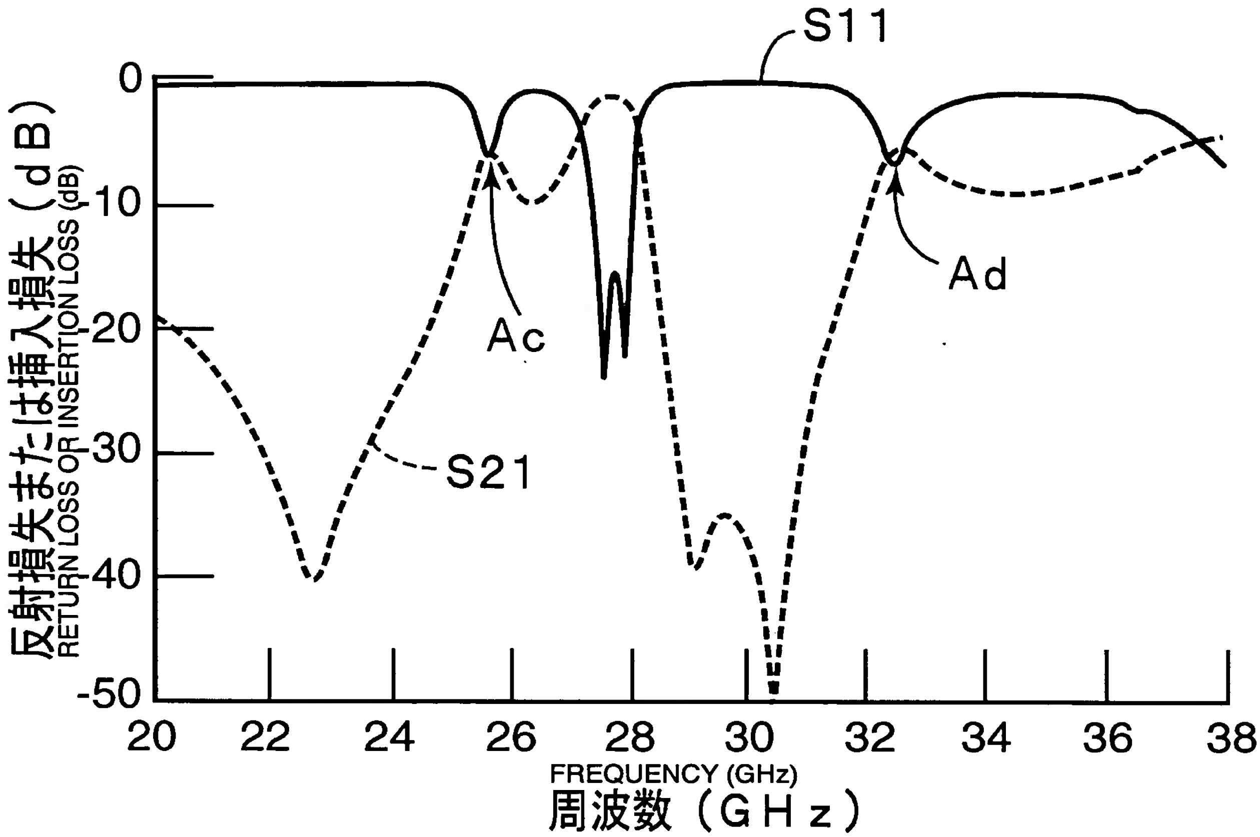
【図５】 [FIG. 5]


S11
S21
Ab
共振器電極
の共振
RESONANCE OF
RESONATOR
ELECTRODE
反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
0
-10
-20
-30
-40
-50
20
22
24
26
28
30
32
34
36
38
FREQUENCY (GHz)
周波数（ＧＨｚ）

【図６】 [FIG. 6]



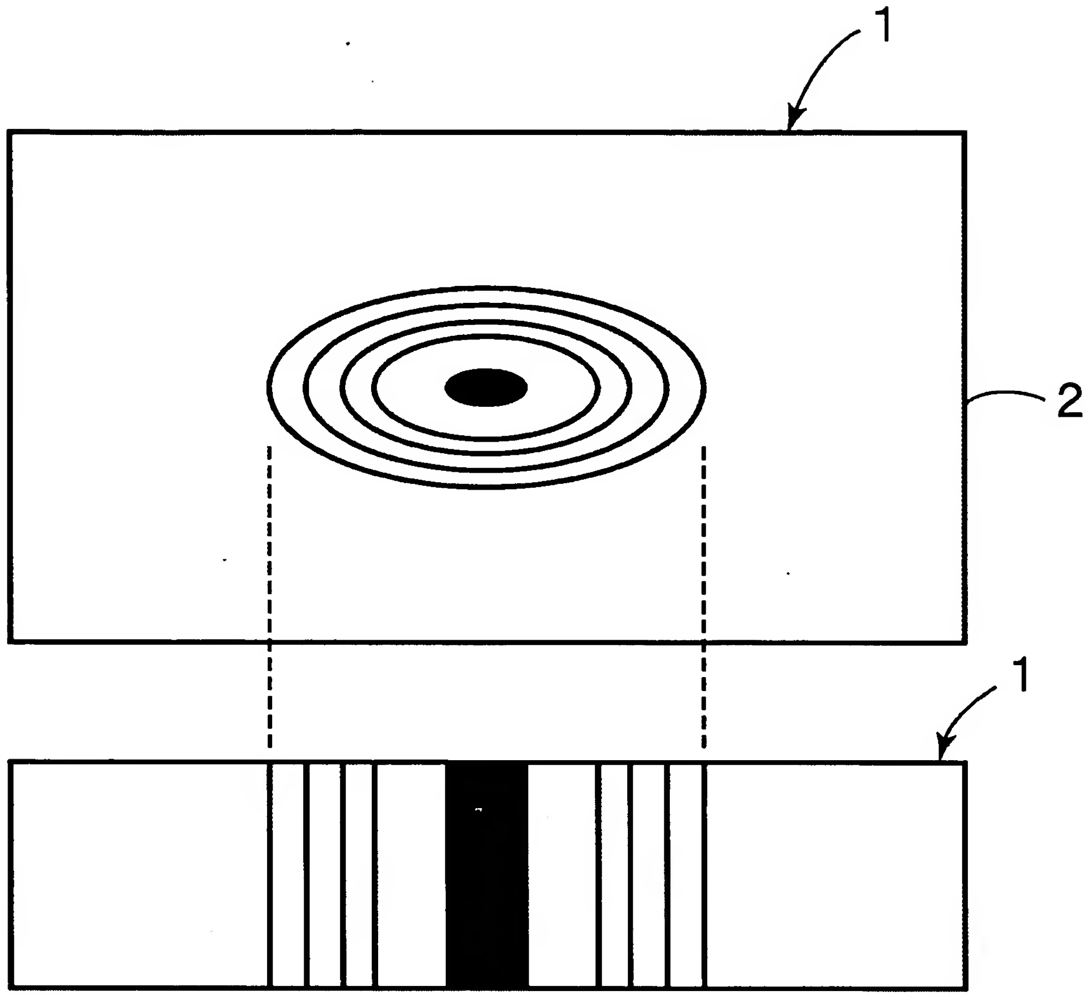
【図７】 [FIG. 7]


S11
S21
Ac
Ad
反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
0
10
20
30
40
-50
20
22
24
26
28
30
32
34
36
38
FREQUENCY (GHz)
周波数（ＧＨｚ）

【図８】 [FIG. 8]

(a)

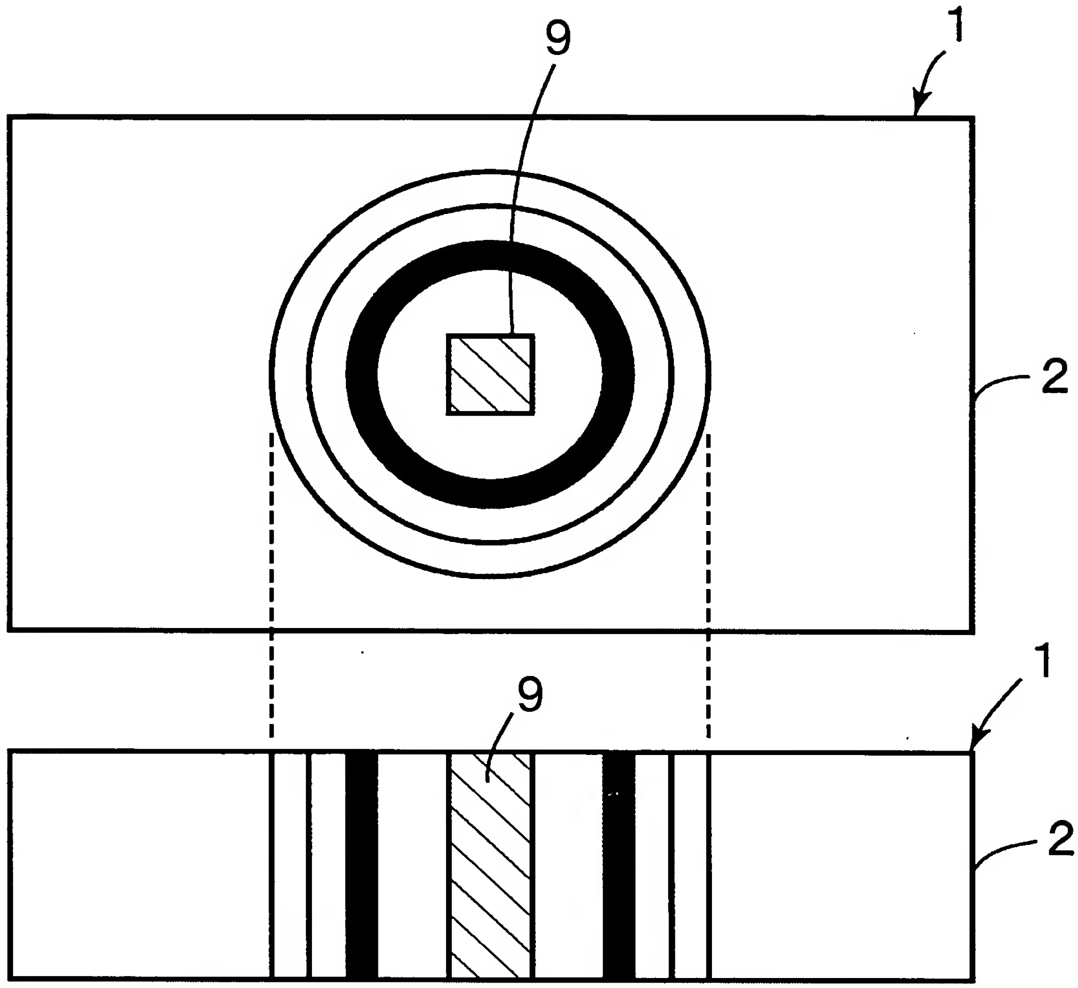
(b)



【図９】 [FIG. 9]

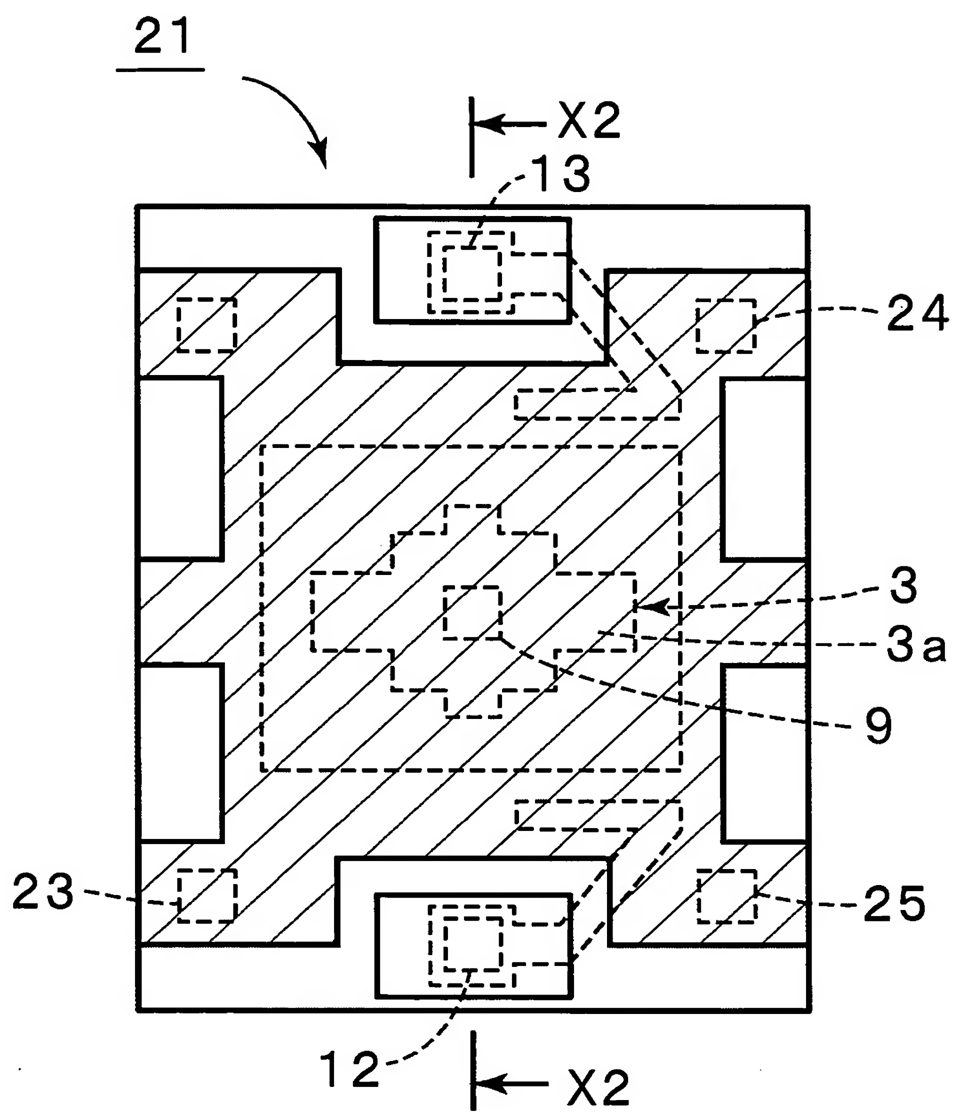
(a)

(b)

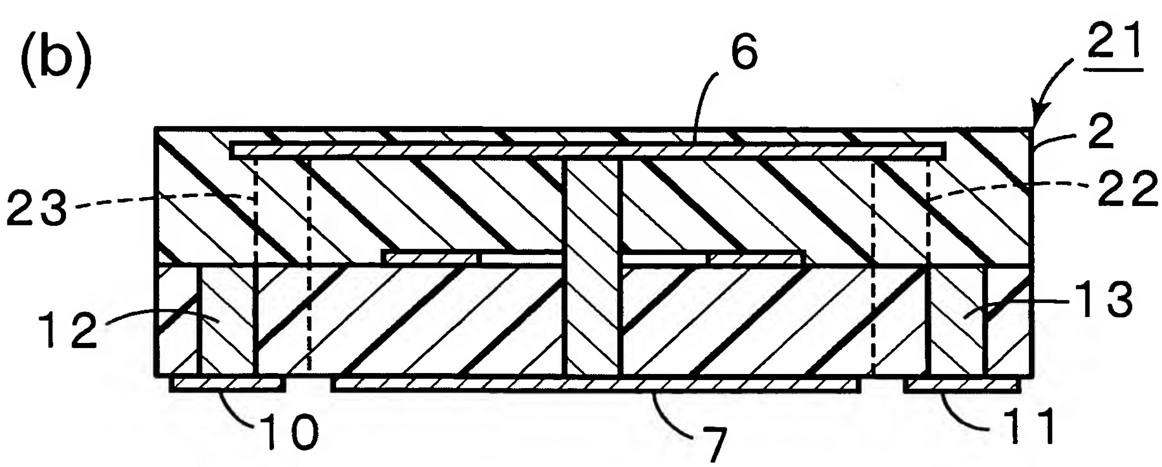


【図１０】 [FIG. 10]

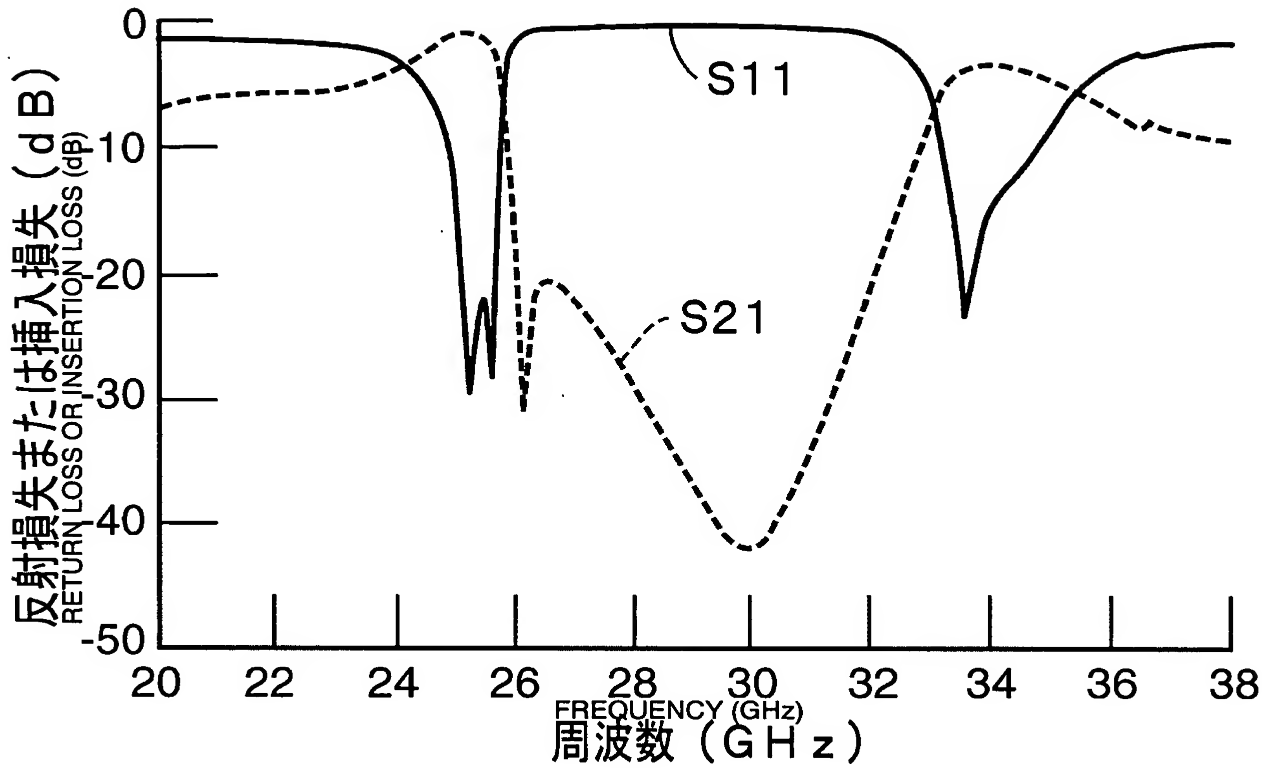
(a)



(b)

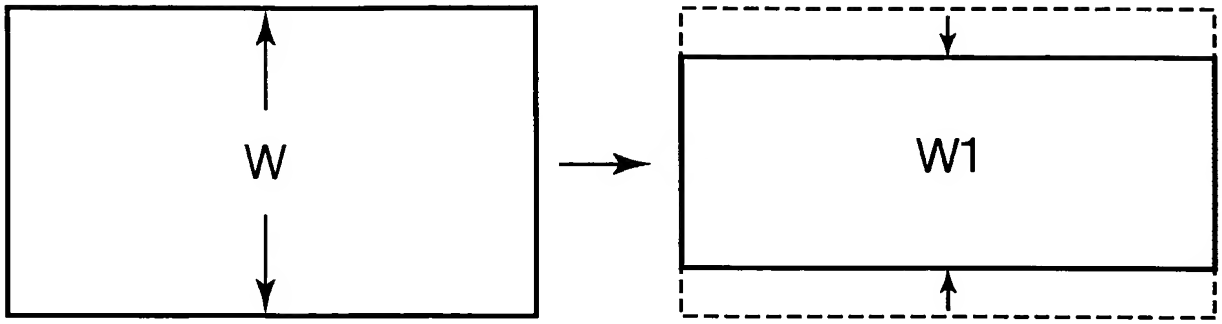


【図１１】 [FIG. 11]

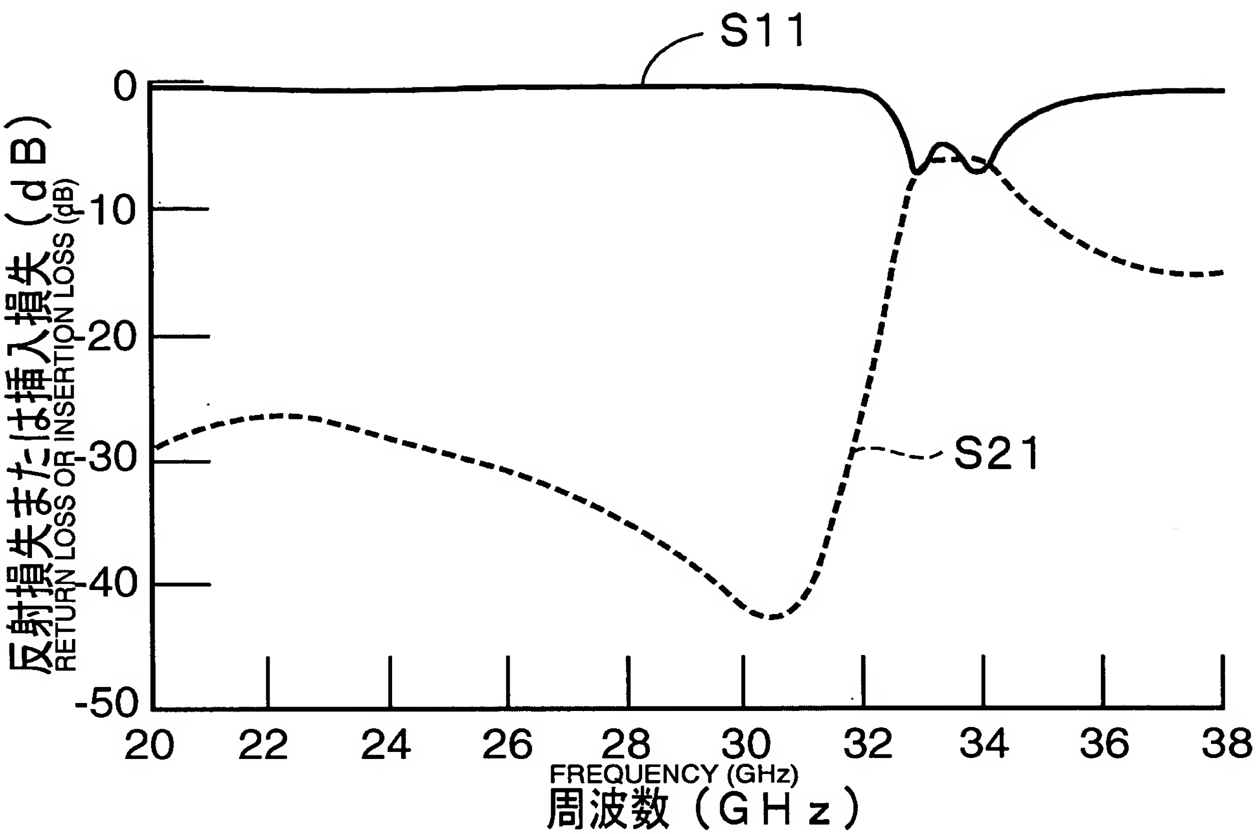


反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
0
-10
-20
-30
-40
-50
S11
S21
20
22
24
26
28
30
32
34
36
38
FREQUENCY (GHz)
周波数（ＧＨｚ）

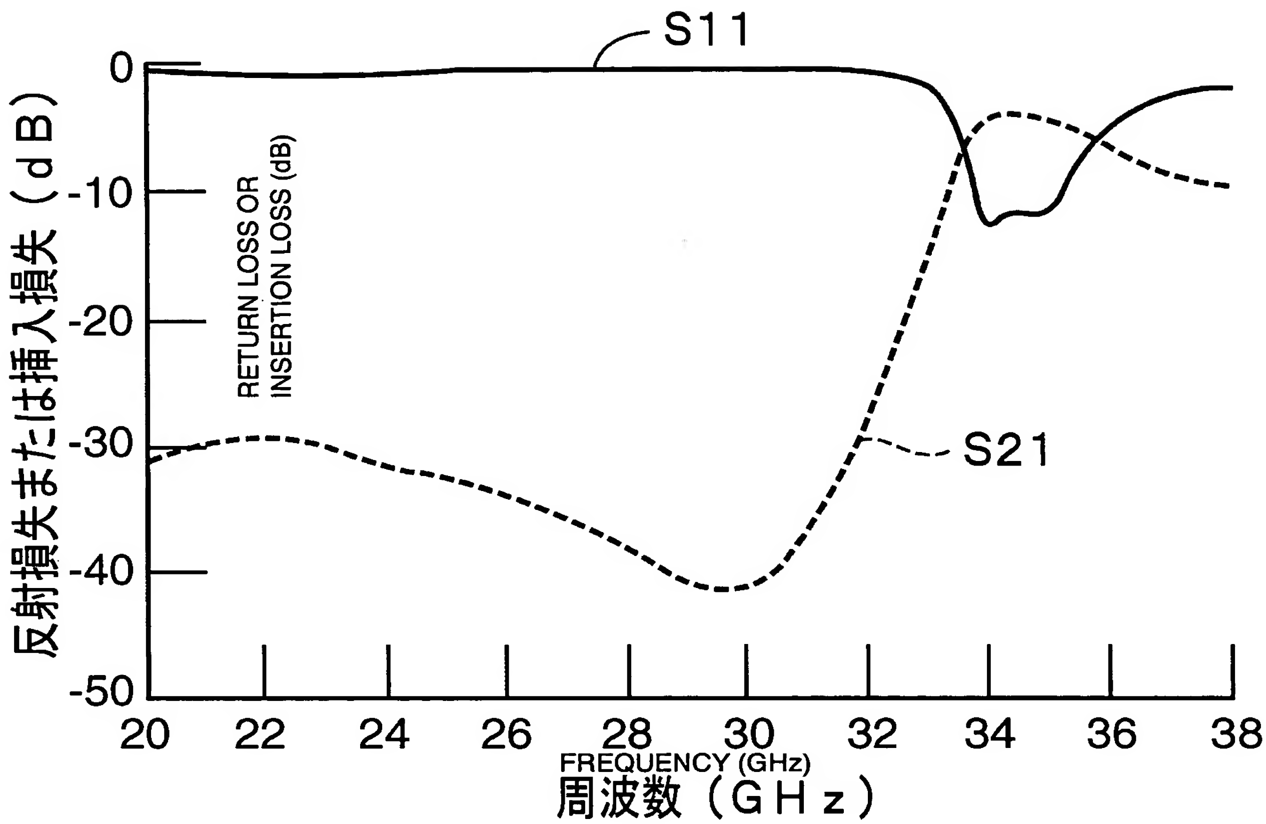
【図１２】 [FIG. 12]



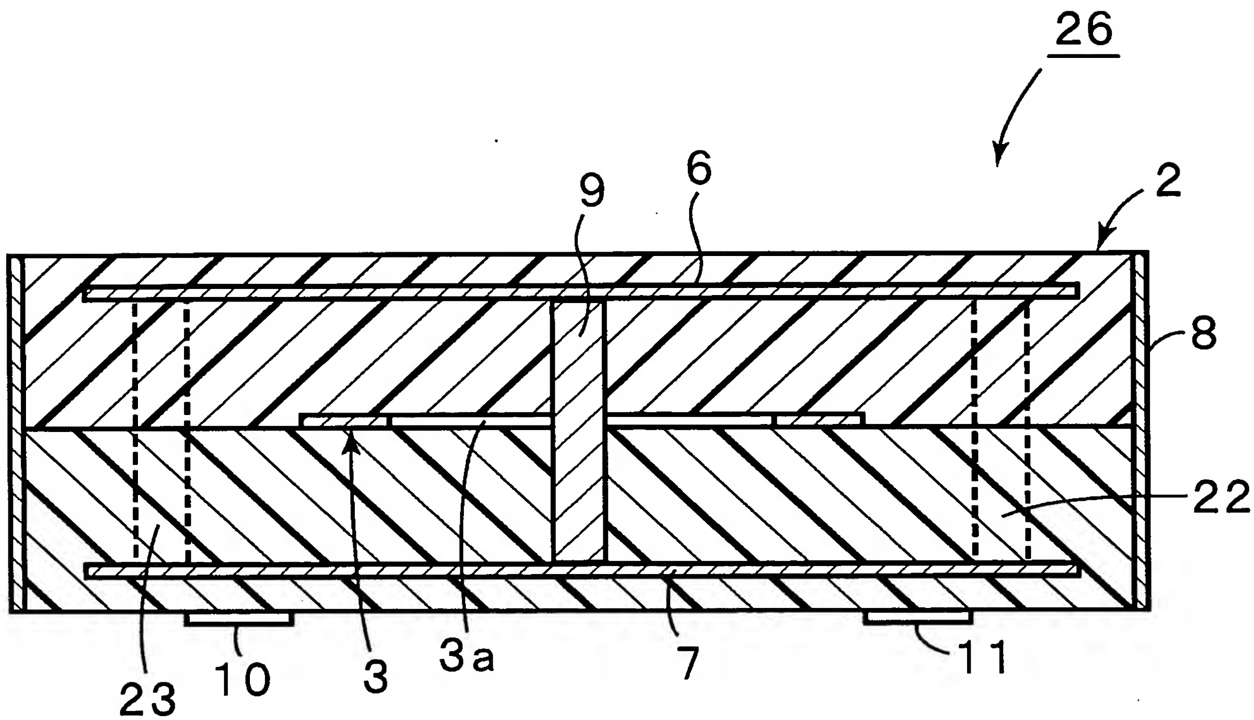
【図１３】 [FIG. 13]


S11
S21
反射損失または挿入損失（dB）
RETURN LOSS OR INSERTION LOSS (dB)
0
-10
-20
-30
-40
-50
20
22
24
26
28
30
32
34
36
38
FREQUENCY (GHz)
周波数（GHz）

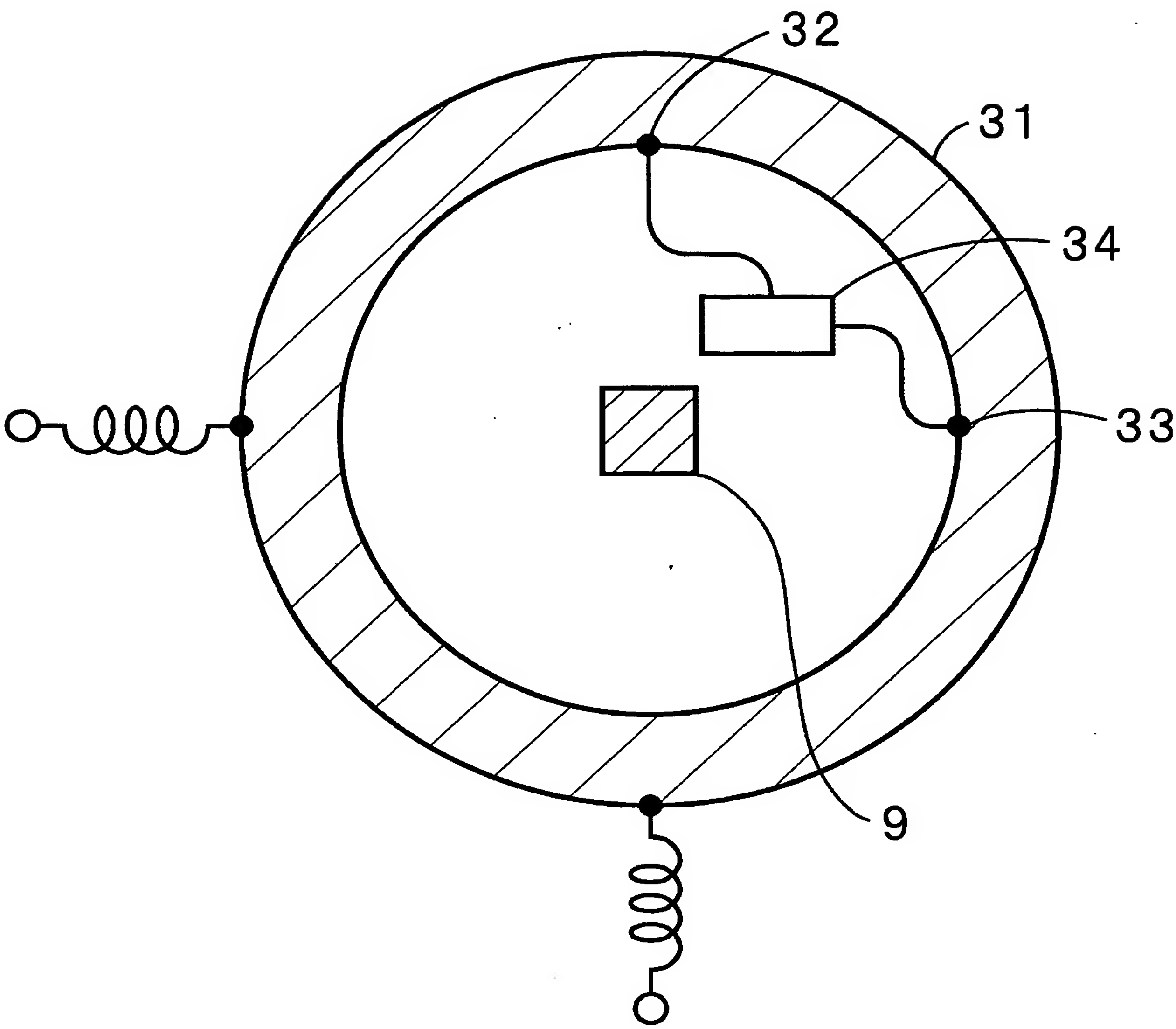
【図１４】 [FIG. 14]


S11
S21
0
-10
-20
-30
-40
-50
20
22
24
26
28
30
32
34
36
38
反射損失または挿入損失（ｄＢ）
RETURN LOSS OR INSERTION LOSS (dB)
FREQUENCY (GHz)
周波数（ＧＨｚ）

【図１５】 [FIG. 15]



【図１６】 [FIG. 16]



【図１７】 [FIG. 17]